Twin Research and Human Genetics
Volume 15 ▌ Number 4 ▌ pp. 541–546 ▌ © The Authors 2012 ▌ doi:10.1017/thg.2012.26

Neonatal Morbidity in Growth-Discordant Monochorionic Twins: Comparison Between the Larger and the Smaller Twin

Enrico Lopriore,[1] Carolien Sluimers,[2] Suzanne A. Pasman,[2] Johanna M. Middeldorp,[2] Dick Oepkes,[2] and Frans J. Walther[1]
[1]Division of Neonatology, Department of Pediatrics, Leiden University Medical Center, Leiden, The Netherlands
[2]Division of Fetal Medicine, Department of Obstetrics, Leiden University Medical Center, Leiden, The Netherlands

Fetal growth restriction in singletons has been shown to enhance fetal lung maturation and reduce the risk of respiratory distress syndrome due to increased endogenous steroid production. However, data on lung maturation in growth-discordant monochorionic (thus, identical) twins are lacking. Our objective was to compare the risk of severe neonatal morbidity between the larger and the smaller twin in monochorionic twins with birth weight discordance (BWD). We included in the study all consecutive monochorionic diamniotic pregnancies with severe BWD (≥25%) and two live-born twins delivered at our center ($n = 47$ twin pairs). We compared the incidence of neonatal morbidity, particularly respiratory distress syndrome (RDS), and cerebral lesions between the larger and the smaller co-twin. The incidence of severe neonatal morbidity in the larger and smaller twin was 38% (18/47) and 19% (9/47), respectively (odds ratio (OR) 2.66, 95% confidence interval (CI) 0.94–7.44) and was due primarily to the higher incidence of RDS, 32% (15/47) and 6% (3/47), respectively (OR 6.88, 95% CI 1.66–32.83). In conclusion, this study shows that the larger twin in monochorionic twin pairs with BWD is at increased risk of severe neonatal morbidity, particularly RDS, compared to the smaller twin.

■ **Keywords:** monochorionic twins, selective intrauterine growth restriction, birth weight discordance, neonatal morbidity, respiratory distress syndrome, cerebral lesions

Monochorionic (MC) twin pregnancies are at risk for several disorders including twin-to-twin transfusion syndrome (TTTS), twin anemia–polycythemia sequence, and twin reversed arterial perfusion. In addition, MC twin pregnancies are at increased risk of birth weight discordance (BWD). The most common cause of this condition is unequal placental sharing (Chang et al., 2009). The prevalence of BWD in MC twins is increased compared to dichorionic twins, affecting up to 25% of MC twin pregnancies, and is associated with high rates of perinatal mortality and morbidity (Adegbite et al., 2005; Lewi et al., 2008b; Russell et al., 2007).

The obstetric management in MC twins with BWD is not well established and includes expectant management, elective preterm birth, fetoscopic laser coagulation of the vascular anastomoses, and selective feticide (Lewi et al., 2008a; Lewi et al., 2008b; Lewi et al., 2010). A major factor influencing the obstetrical management, in particular the timing of delivery, is the increased risk (9–15%) of intrauterine fetal demise (IUFD) in the smaller twin (Lewi et al., 2008a; Lewi et al., 2008b; Lewi et al., 2010). In case of IUFD, which may occur unexpectedly, the larger co-twin may exsanguinate through the vascular anastomoses, resulting in double fetal demise or cerebral injury due to hypoxic injury (Lewi et al., 2008b; Lewi et al., 2010). Even in the absence of co-twin demise, the larger twin has been reported to be at increased risk (up to 37%) of severe cerebral lesions (Gratacos et al., 2004; Ishii et al., 2009). In addition, several studies in twins in general (not stratified by chorionicity) have shown that the larger twin has an increased risk of respiratory distress syndrome (RDS) compared to the smaller twin due to induced preterm delivery (Canpolat et al., 2006; Webb and Shaw, 2001).

RECEIVED 9 November 2011; ACCEPTED 1 March 2012.

ADDRESS FOR CORRESPONDENCE: Enrico Lopriore, Division of Neonatology, Department of Pediatrics, J6-S, Leiden University Medical Center, PO Box 9600, 2300 RC, Leiden, The Netherlands. E-mail: e.lopriore@lumc.nl

The aim of our study was to analyze the incidence of neonatal and neurological morbidity in MC twins with BWD. We hypothesized that the larger twin has an increased risk of RDS and severe neonatal morbidity compared to the smaller co-twin.

Methods

All consecutive MC diamniotic twins with BWD delivered at our center between April 2002 and April 2011 were included in this retrospective study. Inter-twin BWD was defined as a difference in birth weight ≥25% and was calculated using the following formula: (birth weight larger twin – birth weight smaller twin)/birth weight larger twin × 100%. Perinatal outcome data on all MC twins delivered at our center are prospectively entered in our dedicated database. We used the database to retrieve all required medical information for this study. We included only MC twin pregnancies who delivered >24 weeks' gestation and resulted in two live-born twins. Exclusion criteria were: MC twins with TTTS, monoamnionicity, congenital anomaly, and MC triplets (or higher order). Diagnosis of TTTS was based on internationally accepted standardized antenatal ultrasound criteria (Senat et al., 2004).

We recorded the presence of early or late estimated fetal weight (EFW) difference (defined as the detection of EFW discordance before or after 20 weeks' gestation, respectively) and the presence of selective intrauterine growth restriction (sIUGR; defined as an EFW below the 10th percentile in one twin) (Hadlock et al., 1991).

All included cases with sIUGR were retrospectively classified according to the classification system recently proposed by Gratacos et al. based on the umbilical artery Doppler flow characteristics: type I (persistently positive end-diastolic flow), type II (persistently absent or reversed end-diastolic flow (AREDF), or type III (intermittent AREDF) (Gratacos et al., 2007).

Primary outcome was the incidence of neonatal mortality and severe neonatal morbidity, particularly RDS. Severe neonatal morbidity was defined as a composite outcome including any of the following: RDS, patent ductus arteriosus, necrotizing enterocolitis (NEC), and/or sepsis.

RDS was defined as respiratory failure requiring mechanical ventilation (including continuous positive airway pressure) and oxygen supplementation in the first 24 hours, and typical radiological findings on chest X-rays. Diagnosis of NEC was made according to Bell's criteria (Bell et al., 1978). Neonatal sepsis was diagnosed in clinically ill neonates with positive blood cultures.

Secondary outcome was the incidence of cerebral injury detected on neonatal cranial ultrasound examination. After birth, cranial ultrasound scans were performed routinely in all MC twins according to our previously described clinical protocol (Lopriore et al., 2006). Intraventricular hemorrhages (IVH) were classified according to Volpe (Volpe, 2001) and periventricular leucomalacia (PVL) was graded according to de Vries et al. (de Vries et al., 1992). Mild cerebral lesions on cranial ultrasound scans were defined as the presence of at least one of the following: IVH grade I or II, PVL grade I, subependymal pseudocysts, and lenticulostriate vasculopathy. Severe cerebral lesions were defined as the presence of at least one of the following: IVH grade III or IV, PVL ≥ grade II, porencephalic cysts, and ventricular dilatation. Ventricular dilatation was present when the width of one or both lateral ventricles exceeded the 97th percentile (Levene, 1981). The study was exempt from Institutional Review Board Approval as ethical approval and informed consent in the Netherlands is not needed for anonymized studies with medical charts.

Statistics

Paired *t*-tests were used to compare normally distributed values between two groups. Differences between dichotomous variables were assessed with the McNemar test. Results of categorical variables were compared using chi-square test. Logistic regression analysis was performed with weight order (larger vs. smaller twin), birth order (first-born vs. second-born twin), and gender as independent variables and RDS or severe neonatal morbidity as dependent variables.

The results of the logistic models were expressed as odds ratio (OR) and 95% confidence intervals (CI). A p-value <.05 was considered to indicate statistical significance. All statistical data were analyzed using SPSS statistics version 17.0 (SPSS Inc., Chicago, IL, USA).

Results

A total of 47 consecutive MC twin pregnancies with BWD ≥ 25% and two live-born twins were delivered at our center during the study period. In almost all MC pregnancies with BWD (94%, 44/47), the smaller twin was growth restricted (EFW < p10). The MC pregnancies with BWD and sIUGR were classified as type I (32%, 14/44), type II (27%, 12/44), and type III (41%, 18/44), according to the staging system from Gratacos et al. (Gratacos et al., 2007). Mean gestational age at birth was 33.2 weeks (range 28–37 weeks). Baseline characteristics are shown in Table 1.

The incidence of severe neonatal morbidity in the larger and smaller twin was 38% (18/47) and 19% (9/47), respectively (OR 2.66, 95% CI 0.94–7.44, $p = .04$) and was due primarily to the higher incidence of RDS, 32% (15/47) and 6% (3/47), respectively (OR 6.88, 95% CI 1.66–32.83, $p < .01$). After logistic regression analysis, being the larger twin was the only significant risk factor for RDS, whereas birth order or gender were not associated with increased risk of RDS. Detailed information on neonatal morbidity and mortality is presented in Table 2.

Cranial ultrasound scans were performed in 98% (92/94) of neonates. We were not able to perform an ultrasound scan

https://doi.org/10.1017/thg.2012.26 Published online by Cambridge University Press

TABLE 1

Baseline Characteristics in the 47 MC Twin Pregnancies With Birth Weight Discordance

sIUGR – *n* (%)	44 (94%)
Early EFW discordance (<20 weeks' gestation) – *n* (%)	23 (49%)
Normal UA Doppler flow (type I) – *n*/*N* (%)	14/44 (35%)
Persistent AREDF in UA (type II) – *n*/*N* (%)	12/44 (26%)
Intermittent AREDF in UA (type III) –*n*/*N* (%)	18/44 (41%)
Gestational age at delivery – weeks[a]	33.2 ± 2.5
Birth Weight smaller twin – grams[a]	1411 ± 421
Birth Weight larger twin – grams[a]	2118 ± 572
Birth Weight Discordance –– %[a]	33.4 ± 8.0
Caesarean section – *n* (%)	26 (55%)
Indication for caesarean section (*n* = 26)	
Maternal indication – *n* (%)	2 (8%)
Fetal distress small twin –– *n* (%)	11 (42%)
Doppler abnormalities + growth restriction small twin –– *n* (%)	9 (35%)
Failed induction –– *n* (%)	2 (8%)
Elective –– *n* (%)	2 (8%)
Full course of corticosteroids prior to delivery – *n* (%)[b]	23/26 (88%)

Note: [a]Value given as mean ± *SD*; [b]Reported for pregnancies with gestational at delivery ≤34 weeks; sIUGR = selective intrauterine growth restriction; EFW = estimated fetal weight; UA = umbilical artery; AREDF = absent or reversed end diastolic flow.

TABLE 2

Neonatal Morbidity and Mortality in the Smaller Versus Larger Twin

	Smaller twin (*n* = 47)	Larger twin (*n* = 47)	*p*-value
Neonatal death – *n* (%)	0 (0%)	1 (2%)	1.0
Severe neonatal morbidity – *n* (%)	9 (19%)	18 (38%)	0.001
Respiratory distress syndrome – *n* (%)	3 (6%)	15 (32%)	0.001
Patent ductus arteriosus – *n* (%)	1 (2%)	5 (11%))	0.125
Necrotising enterocolitis – *n* (%)	1 (2%)	2 (4%)	1.0
Sepsis – *n* (%)	6 (13%)	6 (13%)	1.0

Note: Severe neonatal morbidity is defined as respiratory distress syndrome, patent ductus arteriosus, necrotising enterocolitis, or sepsis.

in one twin pair delivered at 36 weeks' gestation, because both infants were quickly discharged from the hospital due to good clinical condition.

The overall incidence of mild and severe cerebral lesions was 18% (17/92) and 1% (1/92), respectively, and was similar between larger and smaller twins. Detailed information on cerebral lesions is shown in Table 3.

Severe cerebral lesions were detected in only one neonate, the larger twin in a MC twin pregnancy with Gratacos type III, delivered at 28 + 6 weeks' gestation due to fetal distress of the smaller twin. Antenatal steroids had not been administered because of acute deterioration and lack of time. The larger twin suffered from severe respiratory failure due to RDS grade III requiring high-frequency oscillation ventilation and surfactant administration. She gradually developed pulmonary interstitial emphysema and required intensive mechanical ventilation and high levels of oxygen. On day 15, extensive bilateral cystic PVL grade III was detected. These cystic lesions were not detected on previous

TABLE 3

Cerebral Lesions Detected on Neonatal Cranial Ultrasound in the Smaller Versus Larger Twin

	Smaller twin (*n* = 46)	Larger twin (*n* = 46)	*p*-value
IVH grade I – *n* (%)	1 (2%)	1 (2%)	1.0
IVH grade II – *n* (%)	1 (2%)	0 (0%)	n.a.
PVL grade I – *n* (%)	4 (9%)	6 (13%)	0.625
Lenticulostriate vasculopathy – *n* (%)	1 (2%)	1 (2%)	1.0
Subependymal pseudocysts – *n* (%)	2 (4%)	2 (4%)	1.0
Total mild cerebral lesions – *n* (%)	8 (17%)	9 (20%)	0.625
IVH grade III or IV – *n* (%)	0 (0%)	0 (0%)	n.a.
PVL grade II – *n* (%)	0 (0%)	0 (0%)	n.a.
PVL grade III – *n* (%)	0 (0%)	1 (2%)	1.0
Total severe cerebral lesions – *n* (%)	0 (0%)	1 (2%)	1.0

Note: IVH = intraventricular hemorrhage; PVL = periventricular leukomalacia; n.a. = not applicable.

cranial ultrasounds performed on day 1, 3, 7, and 12. Due to increasing respiratory insufficiency and extensive cerebral lesions, intensive care support was withdrawn and the neonate died on day 16. Postmortem cerebral magnetic resonance imaging confirmed the ultrasound findings. The estimated time of origin of the cerebral lesions was 1 week after birth.

Discussion

Fetal growth restriction in singletons has been shown to enhance fetal lung maturation and reduce the risk of RDS due to increased endogenous steroid production caused by chronic intrauterine stress (Gluck and Kulovich, 1973; Torrance et al., 2009; van et al., 2009). In twin pregnancies, the risk of RDS is also reported to be associated with gender and birth order, male infants being more susceptible for RDS and second-born twins being more at risk for perinatal asphyxia and respiratory failure (Canpolat et al., 2006; Webb and Shaw, 2001). In this study, we found that the risk of RDS in the larger twin in MC twins with BWD is increased compared to the smaller twin. Our findings in MC twins confirm several studies performed in twins in general, irrespective of chorionicity. This is the first study to show this correlation in MC twins. Chorionicity is highly relevant to this finding as MC twins are identical twins and potential bias caused by inter-twin genetic differences is thus excluded.

In a study of preterm discordant twin pairs, Yinon et al. found that the incidence of RDS was significantly higher in the presence of sIUGR compared to discordant twin pairs without sIUGR, 35% (17/46) versus 8% (4/50) (Yinon et al., 2005). However, Yinon et al. did not report the difference in RDS between the larger and smaller twins. In a retrospective study of 124 twin pairs (chorionicity not described), Webb and Shaw found that the need for oxygen at 4 hours in twins above 28 weeks gestation was strongly associated with being the larger twin (OR 1.9; 95% CI 1.03–3.46) (Webb and Shaw, 2001). In a large study of 266 twin pairs (chorionicity not

https://doi.org/10.1017/thg.2012.26 Published online by Cambridge University Press

reported), Canpolat et al. reported that being the larger twin was a more important risk factor for RDS (OR 4.5; 95% CI 2.2–9.2) than being male or second-born twin (Canpolat et al., 2006).

In our study, the MC thus identical twins acted as each other's controls for gestational age at birth and maternal factors (including antenatal corticosteroid treatment) which may affect risk of RDS. After logistic regression analysis, birth order and gender were not associated with increased risk of RDS and only weight order (larger vs. smaller twin) was associated with RDS.

This study also shows that the risk of severe cerebral injury in MC twins with BWD is low and does not differ between larger and smaller twins. This is in accordance with several other studies (Chang et al., 2010; Lopriore et al., 2008). However, some studies have shown the opposite, reporting a high incidence (up to 20%) of parenchymal damage in MC twins with sIUGR (Gratacos et al., 2004; Ishii et al., 2009; Quintero et al., 2001). Cerebral damage appeared to be particularly prominent in the larger twin in MC pregnancies with intermittent AREDF (Gratacos et al., 2004; Ishii et al., 2009). Several explanations for the discrepancy in results can be envisaged, such as methodological differences between the studies (e.g., different cranial ultrasound regimens) and the small number of patients included in all these studies, preventing accurate determination of the incidence of cerebral injury. An important factor, which may strongly influence the rate of cerebral injury, is gestational age at delivery. In the cohort from Gratacos et al., mean gestational age at delivery was lower (30.7 weeks' gestation) (Gratacos et al., 2004) than in our cohort and in the study from Chang et al. (33.2 and 33.4 weeks' gestation, respectively) (Chang et al., 2010). Lower gestational age rather than sIUGR or Doppler flow patterns may account for the discrepancy in results between the studies. Detailed analysis of the timing of detection of cystic PVL is required to determine whether cerebral injury in MC twins with sIUGR and/or BWD is due to antenatal factors (such as abnormal Doppler measurements of the umbilical artery) or postnatal factors (such as prematurity). Detection of cystic PVL early after birth (within 1–2 weeks) suggests an antenatal etiology of cerebral injury, whereas late detection (from 2 weeks after delivery onward) suggests a postnatal etiology. In the large twin with cystic PVL reported in this study, the cysts were detected at day 15, suggesting a postnatal etiology associated with prematurity. We hypothesize that in analogy with increased risk of RDS due to lung immaturity, larger twins may also be more susceptible to PVL due to brain immaturity.

Optimal obstetrical management in MC twins with BWD and/or sIUGR is not yet well established. Different management options have been proposed, including expectant management with close surveillance, elective preterm birth, fetoscopic laser coagulation of the vascular anastomoses, and selective feticide (in complicated cases) (Lewi et al., 2010). Management decisions are often based on the risk of fetal demise (which is often difficult to predict and may occur unexpectedly) in the smaller twin and on the (controversial) risk of cerebral morbidity in the larger twin. Each management option has its pros and cons that may all affect the incidence of perinatal mortality and cerebral injury in survivors. Elective preterm delivery due to fear of deterioration of the fetal condition of the smaller twin and IUFD prevents fetal demise. However, this may increase the risk of neonatal morbidity (including cerebral injury) due to prematurity, particularly in the larger twin. Expectant management and delayed delivery may reduce prematurity-related morbidity, at a possible cost of the risk of sudden IUFD. Fetoscopic surgical interventions protect the larger twin against exsanguination in case of fetal demise of the smaller twin, but may also lead to complications such as premature rupture of the membranes and preterm delivery. In addition, performance of laser coagulation of vascular anastomoses is technically more challenging in the absence of a polyhydramnios–oligohydramnios situation. In addition, fetoscopic laser may also be a complicated way to achieve a selective reduction as the unequal placental sharing is unlikely to improve the situation for the smaller twin.

Our study was not designed to address obstetrical management. Our data may support the hypothesis that delaying delivery of a high-risk growth restricted twin reduces the risk of adverse effects such as RDS in the larger twin, without increasing the risk of cerebral injury. However, the lack of cranial injury findings may be explained by the study design alone and cannot be extrapolated to antenatal care. Recently, Weisz et al. reported severe cranial injury in 11% of infants but 22% of pregnancies in a small prospective study (Weisz et al., 2011).

Further studies, preferably randomized trials, are warranted to guide fetal medicine specialists and help determining optimal obstetrical management in MC twin pregnancies with BWD and/or sIUGR, including optimization of diagnostic tools (Doppler ultrasound, EFW measurements, cardiotocogram).

Our data should be interpreted with care due to the retrospective nature of the study and the relatively small sample size.

In conclusion, we report a higher risk of RDS and severe neonatal morbidity in the larger twin in MC twins with BWD. As this may seem to be counterintuitive, it is important to be aware of this risk in antenatal counseling, as the small twin may be perceived by parents (and physicians) to be at greater risk of morbidity. In addition, we report no increased incidence of severe cerebral injury in the larger twin, but suggest that the possible association reported in the literature may in part have an 'iatrogenic' etiology due to early induced delivery and subsequent injury caused by prematurity. Further studies are urgently needed to determine the optimal management and timing of delivery in these high-risk pregnancies.

https://doi.org/10.1017/thg.2012.26 Published online by Cambridge University Press

Disclosure of Interests

The authors report no conflict of interest.

References

Adegbite, A. L., Castille, S., Ward, S., & Bajoria, R. (2005). Prevalence of cranial scan abnormalities in preterm twins in relation to chorionicity and discordant birth weight. *European Journal of Obstetrics, Gynecology and Reproductive Biology*, *119*, 47–55.

Bell, M. J., Ternberg, J. L., Feigin, R. D., Keating, J. P., Marshall, R., Barton, L., & Brotherton, T. (1978). Neonatal necrotizing enterocolitis. Therapeutic decisions based upon clinical staging. *Annals of Surgery*, *187*, 1–7.

Canpolat, F. E., Yurdakok, M., Korkmaz, A., Yigit, S., & Tekinalp, G. (2006). Birthweight discordance in twins and the risk of being heavier for respiratory distress syndrome. *Twin Research and Human Genetics*, *9*, 659–663.

Chang, Y. L., Chang, S. D., Chao, A. S., Hsieh, P. C., Wang, C. N., & Wang, T. H. (2009). Clinical outcome and placental territory ratio of monochorionic twin pregnancies and selective intrauterine growth restriction with different types of umbilical artery Doppler. *Prenatal Diagnosis*, *29*, 253–256.

Chang, Y. L., Chang, S. D., Chao, A. S., Lien, R., Cheng, P. J., & Chueh, H. Y. (2010). Low rate of cerebral injury in monochorionic twins with selective intrauterine growth restriction. *Twin Research and Human Genetics*, *13*, 109–114.

de Vries, L. S., Eken, P., & Dubowitz, L. M. (1992). The spectrum of leukomalacia using cranial ultrasound. *Behavioral Brain Research*, *49*, 1–6.

Gluck, L., & Kulovich, M. V. (1973). Lecithin-sphingomyelin ratios in amniotic fluid in normal and abnormal pregnancy. *American Journal of Obstetrics and Gynecology*, *115*, 539–546.

Gratacos, E., Carreras, E., Becker, J., Lewi, L., Enriquez, G., Perapoch, J., Higueras, T., Cabero, L., & Deprest, J. (2004). Prevalence of neurological damage in monochorionic twins with selective intrauterine growth restriction and intermittent absent or reversed end-diastolic umbilical artery flow. *Ultrasound in Obstetrics and Gynecology*, *24*, 159–163.

Gratacos, E., Lewi, L., Munoz, B., Acosta-Rojas, R., Hernandez-Andrade, E., Martinez, J. M., Carreras, E., & Deprest, J. (2007). A classification system for selective intrauterine growth restriction in monochorionic pregnancies according to umbilical artery Doppler flow in the smaller twin. *Ultrasound in Obstetrics and Gynecology*, *30*, 28–34.

Hadlock, F. P., Harrist, R. B., & Martinez-Poyer, J. (1991). In utero analysis of fetal growth: A sonographic weight standard. *Radiology*, *181*, 129–133.

Ishii, K., Murakoshi, T., Takahashi, Y., Shinno, T., Matsushita, M., Naruse, H., Torii, Y., Sumie, M., & Nakata, M. (2009). Perinatal outcome of monochorionic twins with selective intrauterine growth restriction and different types of umbilical artery Doppler under expectant management. *Fetal Diagnosis and Therapy*, *26*, 157–161.

Levene, M. I. (1981). Measurement of the growth of the lateral ventricles in preterm infants with real-time ultrasound. *Archives of Diseases in Childhood*, *56*, 900–904.

Lewi, L., Gucciardo, L., Huber, A., Jani, J., Van Mieghem, T., Done, E., Cannie, M., Gratacos, E., Diemert, A., Hecher, K., Lewi, P., & Deprest, J. (2008a). Clinical outcome and placental characteristics of monochorionic diamniotic twin pairs with early- and late-onset discordant growth. *American Journal of Obstetrics and Gynecology*, *199* (5), 511.e1–511.e7.

Lewi, L., Gucciardo, L., Van, M. T., De, K. P., Beck, V., Medek, H., Van, S. D., Devlieger, R., De, C. L., & Deprest, J. (2010). Monochorionic diamniotic twin pregnancies: Natural history and risk stratification. *Fetal Diagnosis and Therapy*, *27*, 121–133.

Lewi, L., Jani, J., Blickstein, I., Huber, A., Gucciardo, L., Van Mieghem, T., Done, E., Boes, A. S., Hecher, K., Gratacos, E., Lewi, P., & Deprest, J. (2008b). The outcome of monochorionic diamniotic twin gestations in the era of invasive fetal therapy: A prospective cohort study. *American Journal of Obstetrics and Gynecology*, *199*, 514–518.

Lopriore, E., Slaghekke, F., Vandenbussche, F. P., Middeldorp, J. M., Walther, F. J., & Oepkes, D. (2008). Cerebral injury in monochorionic twins with selective intrauterine growth restriction and/or birthweight discordance. *American Journal of Obstetrics and Gynecology*, *199* (6), 628.e1–628.e5.

Lopriore, E., Wezel-Meijler, G., Middeldorp, J. M., Sueters, M., Vandenbussche, F. P., & Walther, F. J. (2006). Incidence, origin, and character of cerebral injury in twin-to-twin transfusion syndrome treated with fetoscopic laser surgery. *American Journal of Obstetrics and Gynecology*, *194*, 1215–1220.

Quintero, R. A., Bornick, P. W., Morales, W. J., & Allen, M. H. (2001). Selective photocoagulation of communicating vessels in the treatment of monochorionic twins with selective growth retardation. *American Journal of Obstetrics and Gynecology*, *185*, 689–696.

Russell, Z., Quintero, R. A., & Kontopoulos, E. V. (2007). Intrauterine growth restriction in monochorionic twins. *Seminars in Fetal and Neonatal Medicine*, *12*, 439–449.

Senat, M. V., Deprest, J., Boulvain, M., Paupe, A., Winer, N., & Ville, Y. (2004). Endoscopic laser surgery versus serial amnioreduction for severe twin-to-twin transfusion syndrome. *New England Journal of Medicine*, *351*, 136–144.

Torrance, H. L., Derks, J. B., Scherjon, S. A., Wijnberger, L. D., & Visser, G. H. (2009). Is antenatal steroid treatment effective in preterm IUGR fetuses? *Acta Obstetrica Gynecologica Scandinavica*, *88*, 1068–1073.

van Stralen, G., van der Bos, J., Lopriore, E., Te Pas, A. B., Bloemenkamp, K. W., Walther, F. J., & Scherjon, S. (2009). No short-term benefits of antenatal corticosteroid treatment in severely preterm growth restricted fetuses: A case-control study. *Early Human Development*, *85*, 253–257.

Volpe, J. J. (2001). Intracranial hemorrhage: Germinal matrix-intraventricular hemorrhage of the premature infant. In: J. J. Volpe (Ed.), *Neurology of the newborn*. (4th ed., pp. 428–493). Philadelphia: Saunders.

https://doi.org/10.1017/thg.2012.26 Published online by Cambridge University Press

Webb, R. D., & Shaw, N. J. (2001). Respiratory distress in heavier versus lighter twins. *Journal of Perinatal Medicine*, *29*, 60–63.

Weisz, B., Hogen, L., Yinon, Y., Gindes, L., Shrim, A., Simchen, M., Schiff, E., & Lipitz, S. (2011). Perinatal outcome of monochorionic twins with selective IUGR compared with uncomplicated monochorionic twins. *Twin Research and Human Genetics*, *14*, 457–462.

Yinon, Y., Mazkereth, R., Rosentzweig, N., Jarus-Hakak, A., Schiff, E., & Simchen, M. J. (2005). Growth restriction as a determinant of outcome in preterm discordant twins. *Obstetrics and Gynecology*, *105*, 80–84.

https://doi.org/10.1017/thg.2012.26 Published online by Cambridge University Press